Field Validation of Respirator Change Out Schedule for PGDN (Otto Fuel II)

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Respirator Change Out Schedule - Background

- 29 CFR 1910.134 (d)(3)(iii)
  - Require respirator change out schedules
    - Based on tests of cartridge breakthrough-worst case conditions of concentration, humidity, temperature
- Chapter 15 OPNAVINST 5100.23F and
  - Outlines Navy policy on Respirators
- Chapter 9 NEHC IHFOM Rev Jan 2003
  - Provides protocol for establishing change out schedule

NEHC Chemical Cartridge Change Out Schedule Protocol

- 4 Steps
  - Characterize exposure
  - Estimate chemical cartridge breakthrough time
    - Respirator manufacturer service life calculators e.g. 3M
  - Determine chemical cartridge change out schedule, i.e. 90% of breakthrough time
  - Verify cartridge change out schedule

Characterize Exposure- MK-48 and ADCAP (Mod 6)

Characterize Exposure- Otto Fuel II

- Torpedo Fuel composed of
  - Propylene glycol dinitrate (PGDN)
    - Colorless liquid with unpleasant odor, explosive, believed to be component that causes health effects
    - Navy OEL 0.3 mg/m^3 8-hr TWA
  - 2-Nitrodiphenylamine
    - Orange solid, stabilizer
  - Dibutyl sebacate
    - Clear liquid, used for making plastics, flavor enhancer

Characterize Exposure- Teardown Tasks

- Separate after-body from fuel tank
- Fuel pump, solenoid, motor and related accessories removed from the afterbody.
- Rest of afterbody disassembled and the parts cleaned in degreasing tanks

Characterize Exposure- Accessories Tasks

- Torpedo accessories, received from Teardown.
- Disassembled in the Accessories work area.
- Speed control valve and a fuel pump valve are removed from each fuel pump.

Characterize Exposure-Accessories Data

- OEL: 0.3 mg/m^3
- Sample Dates:
  - 4 Jun 1992- 9 Oct 2003
- N=35
- Range: 0.008 to 0.575 mg/m^3
- 95th Percentile: 0.474 mg/m^3
- UTL $_{95,95}$ = 0.818 mg/m^3
- GSD= 2.85
- PN% = 11.3%
- Over OEL = 4

Characterize Exposure- Teardown Data

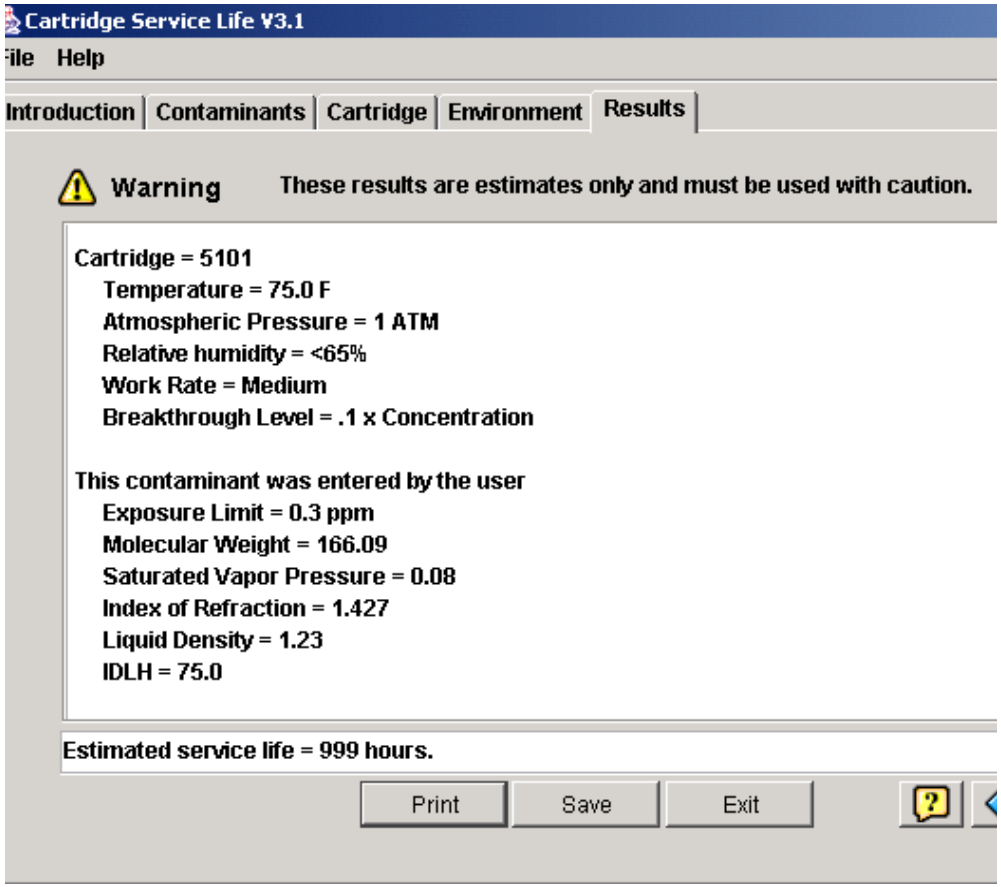
- OEL: 0.3 mg/m^3
- Sample Dates:
  - 12 Feb 1992- 5 Sep 2003
- N=57
- Range: 0.01 to 0. 807 mg/m^3
- 95th Percentile: 0.344 mg/m^3
- UTL $_{95,95}$ = 0.525 mg/m^3
- GSD= 3.02
- PN% = 6.4%
- Over OEL= 6

Estimate Breakthrough Time

- PGDN not tested for chemical cartridge service life
- Used available software to estimate cartridge service life
  - OSHA Advisor genius
  - 3M Cartridge Service Life program v 3.1

3M Cartridge Service Life v 3.1

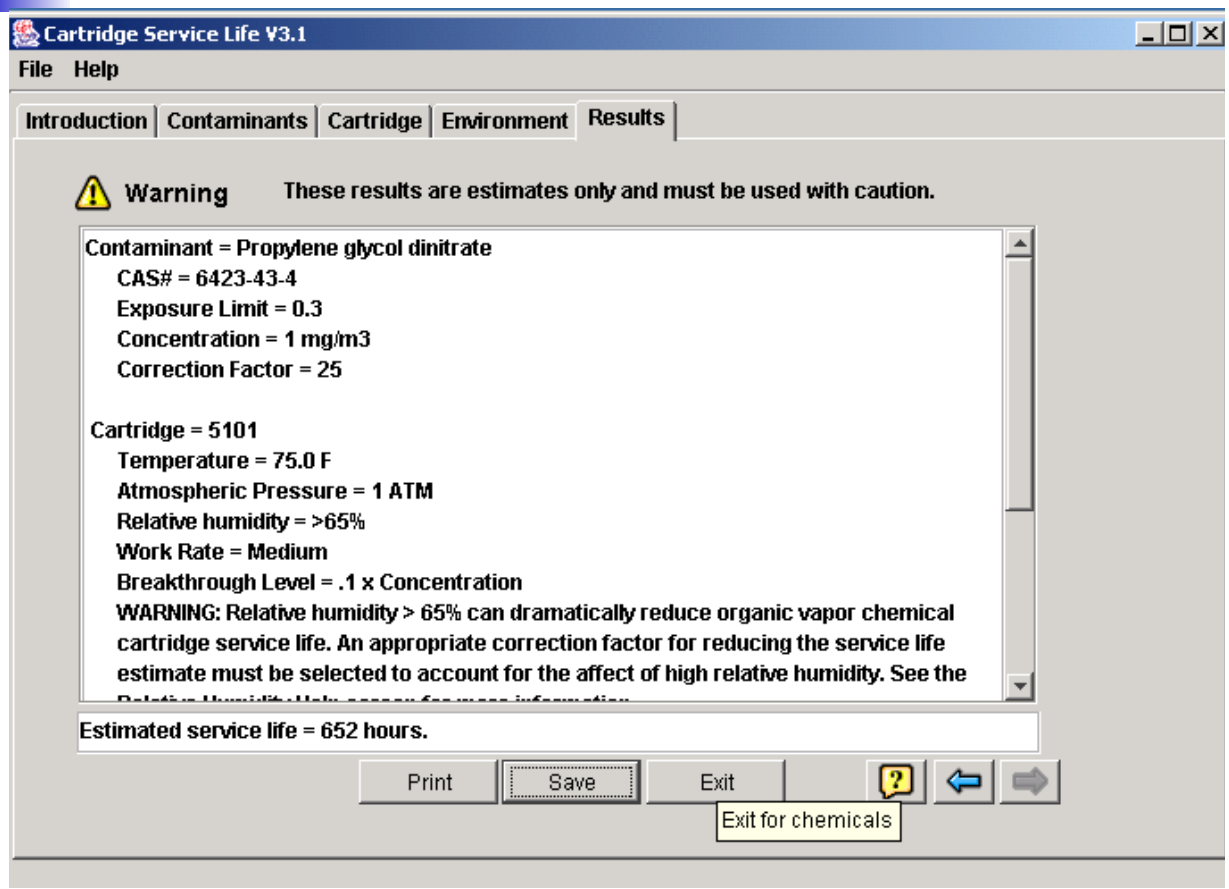
- 3M Cartridge Service Life program v 3.1 to estimate cartridge service life
- Estimated 999 hours



Select change out time - Adjustments

- Cartridge service life estimate 999 hours
- 90% would be ~ 900 hours
- 8 hrs/day → >100 days
  - >85% RH↓ service life by 50%
  - 10% reduction in service life for > 75°F
- Accounting for environmental factors results in 40 days
  - i.e. 60% reduction in calculated value

Service Life with RH Correction

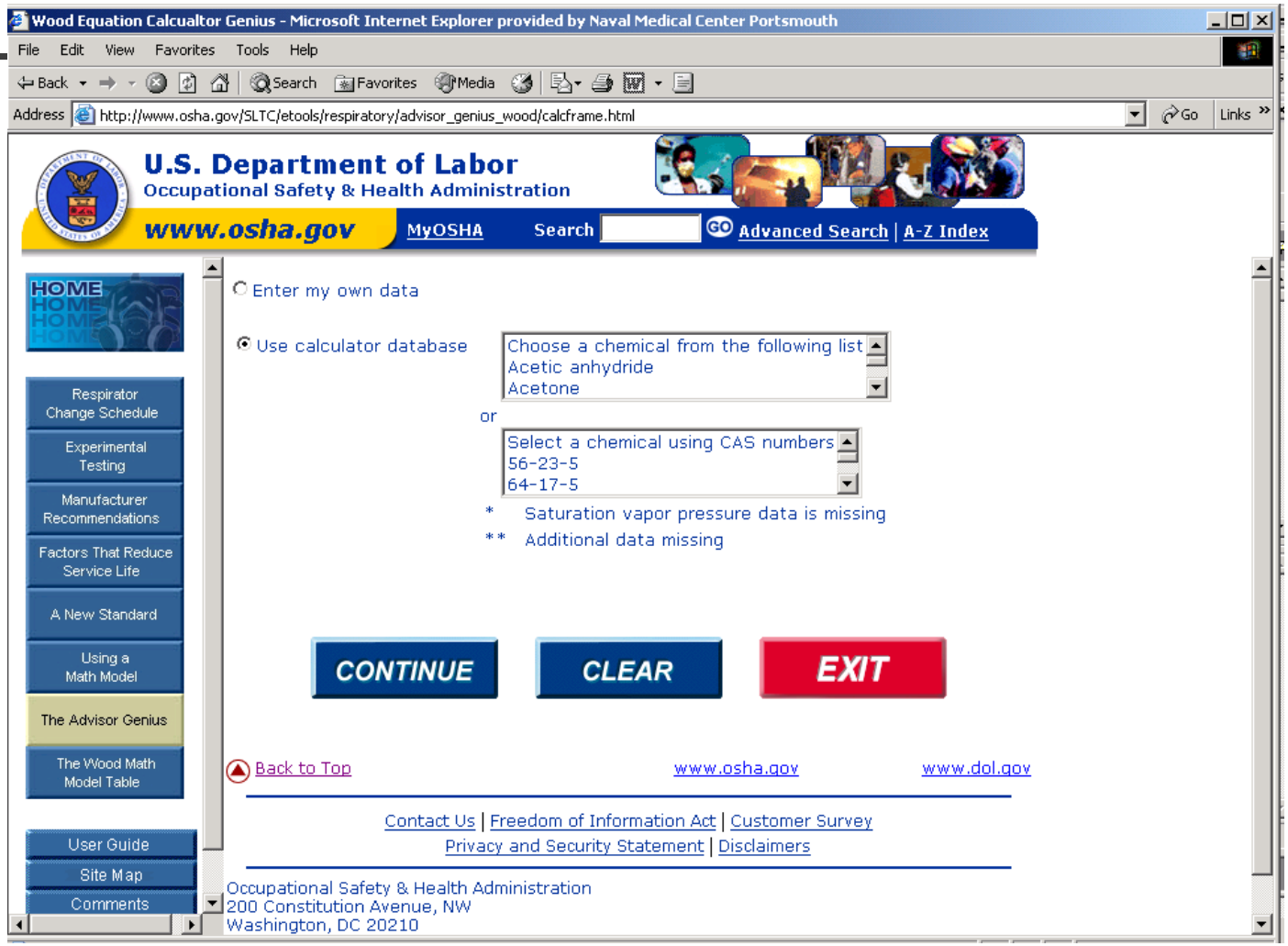

Cartridge Service Life V3.1
File Help
Introduction Contaminants Cartridge Environment Results
Warning These results are estimates only and must be used with caution.
Contaminant = Propylene glycol dinitrate
CAS# = 6423-43-4
Exposure Limit = 0.3
Concentration = 1 mg/m3
Correction Factor = 25
Cartridge = 5101
Temperature = 75.0 F
Atmospheric Pressure = 1 ATM
Relative humidity = >65%
Work Rate = Medium
Breakthrough Level = .1 x Concentration
WARNING: Relative humidity > 65% can dramatically reduce organic vapor chemical cartridge service life. An appropriate correction factor for reducing the service life estimate must be selected to account for the affect of high relative humidity. See the
Estimated service life = 652 hours.
Print
Save
Exit
Exit for chemicals

652 hours

81 days

90% of 81 days = 73 days

OSHA Advisor Genius



OSHA Advisor Genius

- **Breakthrough time**: 450 days
  - Maximum concentration of 1 mg/m^3
  - Breakthrough of 10% of the workplace concentration.
- The breakthrough time assumes RH < 65%.
- The maximum RH expected in the workplace is 85%
  - Divide by 4 to compensate for the higher humidity. Service life of 113 days
- 90% of 113 days = 102 days

Select change out time

- OSHA Advisor
  - 909 hours or 102 days
- 3 M with RH correction
  - 652 hours or 81 days
- 3 M and applying IHFOM corrections for RH and temperature
  - 40 days
- One month selected as change out schedule
  - about 22 working days

Verify Cartridge Change Out Schedule– Strategy

- Simultaneously sample inside and outside respirator
  - MSA full face respirator with HEPA/OV cartridges
  - Inside respirator sampling accomplished by replacing voice diaphragm with MSA supplied sampling port

Sampling Train Setup-Trial 1

Inside Respirator

Verify Cartridge Change Out Schedule– Strategy Continued

- Sample daily first week and then once a week for a month or until breakthrough
  - Breakthrough defined as-- inside respirator concentration >= 25% of OEL ~ 0.08 mg/m^3
  - Close out at end of month
  - Samples taken to lab at end of sampling week
- Results would validate chosen schedule or require a modification

Sampling Calendar

Sun	Mon	Tue	Wed	Thurs	Fri	Sat
May 2004		25	26	27	28	29
30	31					
June 2004		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	

Accessories – 8 days

Teardown – 10 days

Teardown Data – Trial 1

Breakthrough on 3rd day for 1 of 4 workers

		5/25-4T Day 1	5/26-11T Day 2			6/1-6T Day 3		6/8-12T Day 4			6/9-4T Day 5
D	In	<0.02	<0.03	<0.01	0.01	0.12	0.22				
	Out	0.17	0.43	1.29	0.64	0.83	0.88				
W	In	<0.02	<0.02	<0.02	<0.01	0.02	0.01	<0.02	<0.03	0.04	0.02
	Out	0.05	0.07	0.3	0.42	0.29	0.21	0.18	0.82	0.26	0.21
S	In	<0.02	<0.02	1.15	<0.01	0.15	0.02	0.07	0.15	0.13	0.23
	Out	0.31	Void	1.51	0.76	1.0	0.68	0.21	0.76	0.72	0.38
P	In	<0.01	<0.02	<0.02	<0.01	0.04	0.05	0.13	0.05	0.09	0.07
	Out	0.08	0.08	0.25	0.54	.2	0.47	0.76	0.1	0.15	0.14

Fit Issue ?

Teardown Data – Trial 1- Continued

		6/10 10T Day 6		6/15-6T Day 7	6/16-6T Day 8		6/17-4T Day 9	6/18 Closeout
D	In	0.13	0.25	0.21	0.25	0.16	0.27	0.27
	Out	0.61	0.66	0.66	0.31	0.23	0.46	
W	In	<0.05	0.05	0.05		0.29	<0.02	0.11
	Out	0.21	0.4	0.29		0.82	0.26	
S	In	0.22	0.42	0.16		0.34	0.11	0.29
	Out	0.34	0.52	1.96		0.97	0.25	
R	In	0.31	0.07	0.11		0.42		0.11

3rd Day 39 ug

8th Day ? 38 ug

4th Day 48 ug

6th Day 37 ug

Teardown Worker ANOVA - All Workers

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
D	12	-16.91834	-1.4098614	1.035420541
P	12	-22.60682	-1.8839018	0.684967242
S	14	-19.12855	-1.3663249	0.81772396
W	15	-44.10327	-2.9402178	2.333771084

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	23.02423138	3	7.6747438	6.043350824	0.001384	2.793953513
Within Groups	62.22747228	49	1.2699484			
Total	85.25170366	52				

Calculated F>critical F – significant different mean exposures

Teardown Worker ANOVA - Eliminating "W"

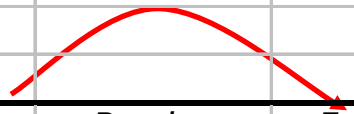
Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
D	12	-16.91834	-1.4098614	1.035421
P	12	-22.60682	-1.8839018	0.684967
S	14	-19.12855	-1.3663249	0.817724

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.044266183	2	1.0221331	1.210457	0.310233748	3.267417
Within Groups	29.5546771	35	0.8444193			
Total	31.59894328	37				



Calculated F < critical F – no significant difference

Accessories Data –Trial 1

		5/25 Day 1	5/27 Day 2	6/1 Day 3	6/8 Day 4	6/10 Day 5	6/16 Day 6	6/18 Day 7	Close Out
E	In	<0.01	0.01	0.06	0.12	0.83	1.02	1.25	0.85
	Out	0.27	0.087	0.19	0.82	0.65	1.12	1.54	
F	In	<0.01	0.01	0.57	0.27	0.25	0.14	0.54	0.78
	Out	0.8	0.12	Void	0.3	4.4	3.77	1.7	

4th day

3rd day

Service Life Issues - Trial 1

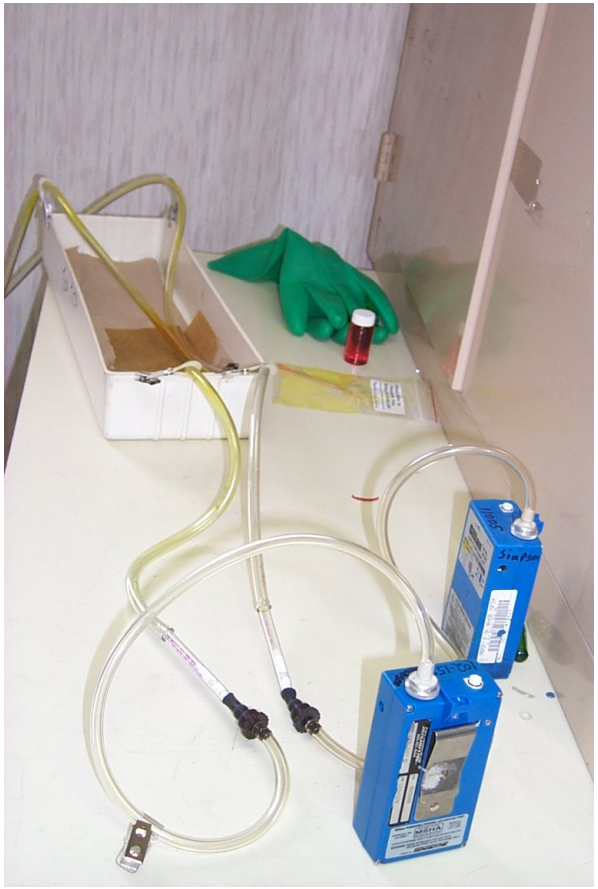
- Service life <<< less than expected
  - Samples showed service life 2 to 7 days
- Why the big difference ?
  - Service life calculator flawed?
    - MSA will do lab study for PGDN breakthrough; OV
  - Incorrect Environmental factors input
    - Actual RH as high as 79%
    - Actual temperature as high 85◦ F
      - Not all days measured
  - Respirator fit ?
  - Sampling train configuration?

Service Life Issues - Trial 1 Sampling Train Configuration

- Initial sampling configuration had a long piece of R 3603 tygon running from the mask to the media.
  - Observed Otto Fuel on tygon.
    - Did PGDN penetrate Tygon?
    - If so, were there sampling gains due to sampling configuration?

Service Life Issues - Trial 1 Penetration

- Performed in house test to determine if PGDN did breakthrough tygon
- Data showed
  - Penetration through Tygon R 3603



Service Life Issues - Trial 1 Wall Loss

- Were there sampling losses due to sampling train configuration?
  - Tygon precedes collection device; is PGDN collected on inside of Tygon R 3603 ?
- Performed in house test to determine if there was wall loss
  - Data showed wall loss using Tygon R 3603

Sampling train modifications

- Data showed
  - Penetration and wall loss with Tygon R 3603
- Based on tests, changed sampling train configuration
- Shortened length of Tygon from media to respirator
  - Reduced chance for PGDN contamination
  - Reduces chance for penetration and wall loss
- Replaced section of train from media to respirator with Tygon 2075

Sampling train Setup- Second Trial

Inside Respirator

Sampling Train Setup Comparison-

First Trial

Second Trial

Accessories Data –Trial 2

		12/7	12/8	12/14	Closeout
E	In	0.11	<0.02	<0.02	<0.08
	Out	0.55	0.34	0.53	
F	In	0.04	<0.02	0.02	<0.08
	Out	0.24	0.29	0.8	

3 days no breakthrough

Work load less, and Cooler temperature

Christmas break

Did not resume

Fit Issue ?

Conclusions-thoughts

- Future chemical cartridge verifications
  - Consider sampling train configuration
    - Penetration-contamination
    - Wall loss
  - Base cartridge service life on samples collected behind cartridge
    - Eliminates fit factor issues
  - Fit factor determinations made by simultaneous inside – outside respirator sampling
- Use caution when applying calculator estimates
  - When no manufacturer recommendations
  - When there are mixtures
  - Especially in summer
- Sample turn around time—Have results quicker
- Measure humidity and temperature – all monitoring days
- Days may not be best change out schedule determinant – workload differences (e.g. # torpedoes disassembled)

PGDN Respirator Change Out Verification Survey

Left to Right

John Hoggard

Bob Edwards, CIH

Jack Ritz